

Summary of the LoopVerein

Sven Heinemeyer, CERN

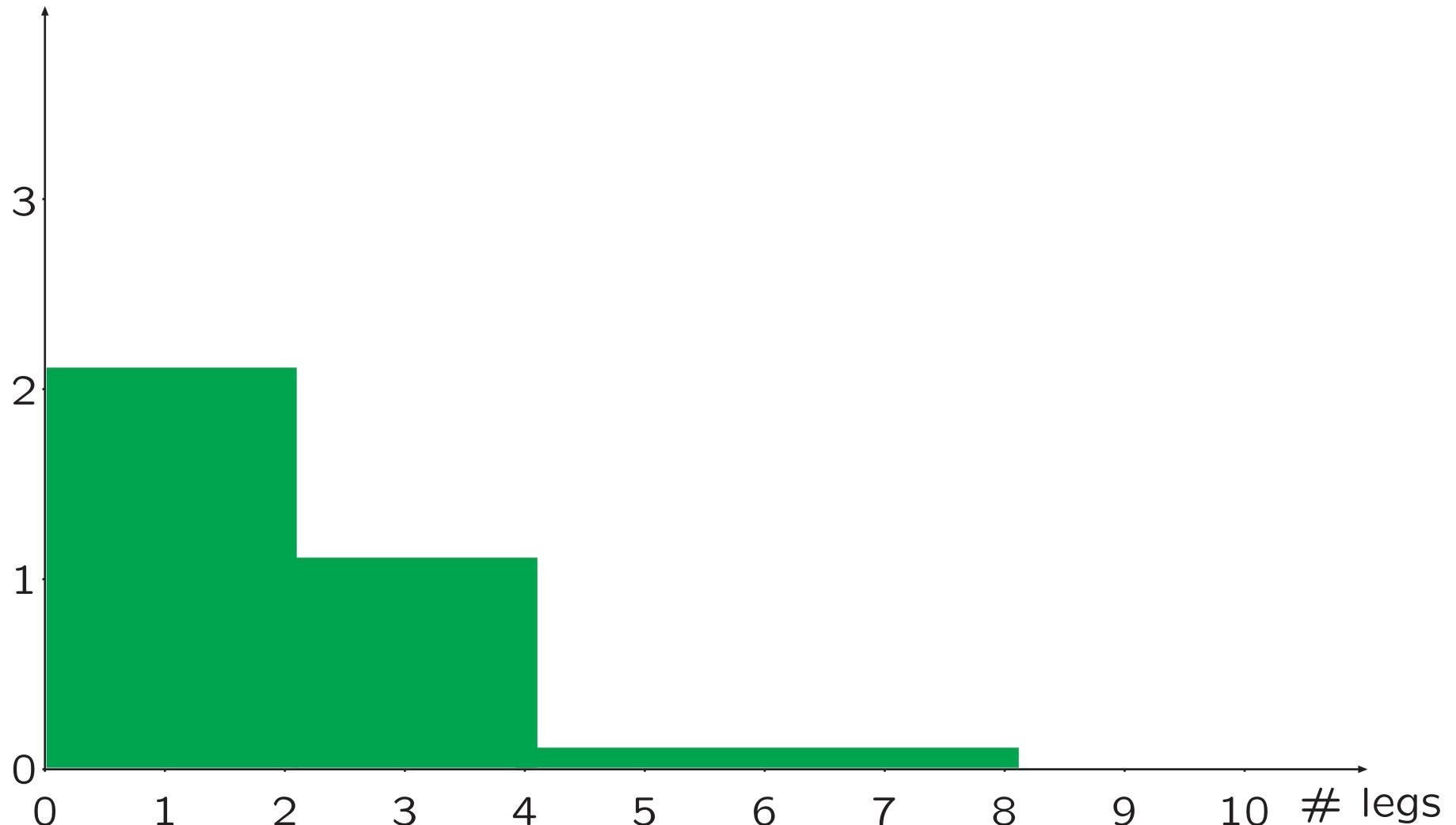
Durham, 09/2004

time is short ⇒ outline is simple (& the usual apologies)

- Status of the field
- Contributions in Durham
- What is needed for the future

loops

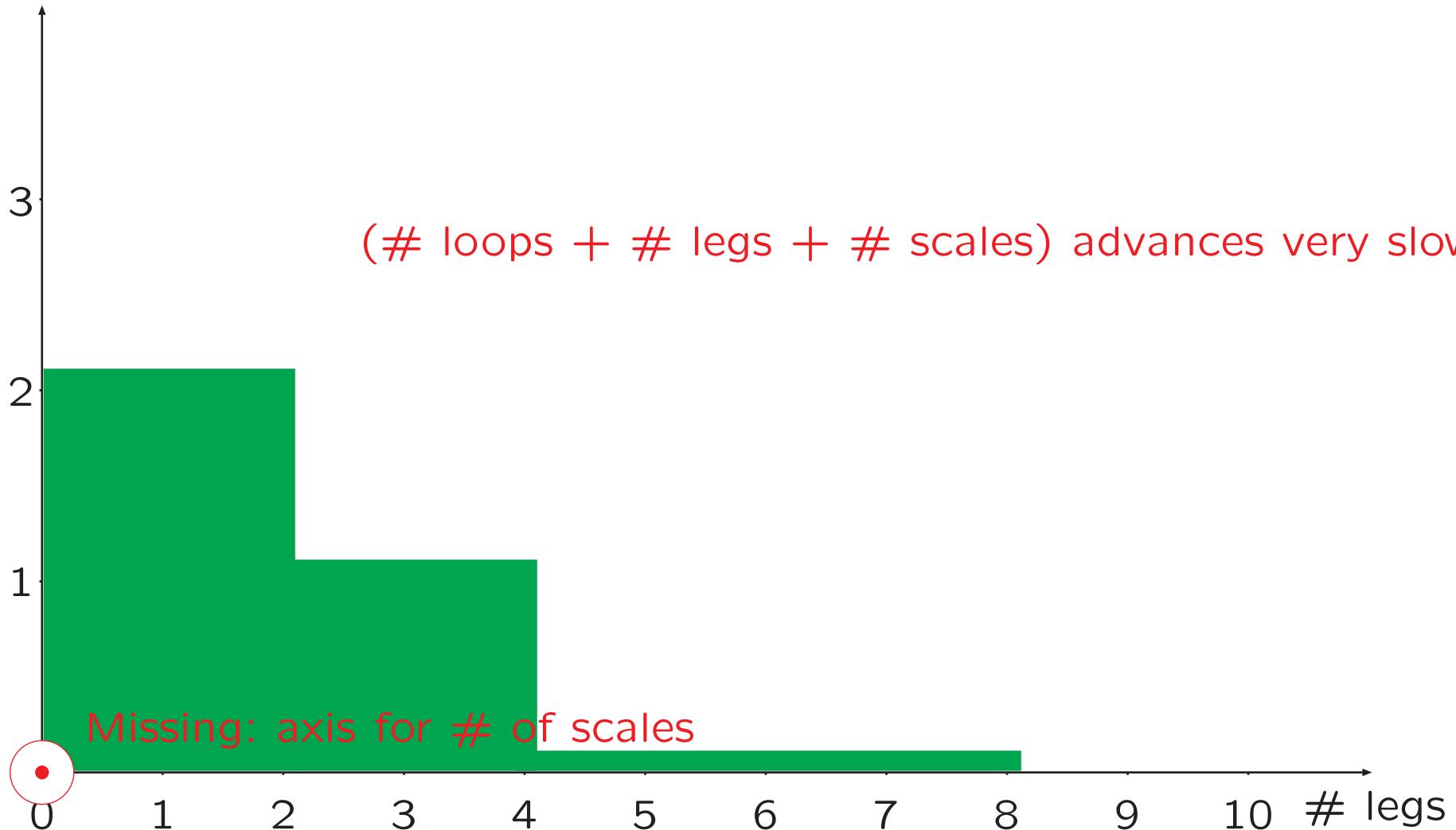
Technique well established



vacuum graphs self-energies $2 \rightarrow 2, 1 \rightarrow 3$ $ee \rightarrow 4f$ $ee \rightarrow 6f$
 $\Delta\rho$ Δr , masses Bhaba $ee \rightarrow 4f + \gamma$
 $1 \rightarrow 2, \sin^2 \theta_{\text{eff}}$ $2 \rightarrow 3$

loops

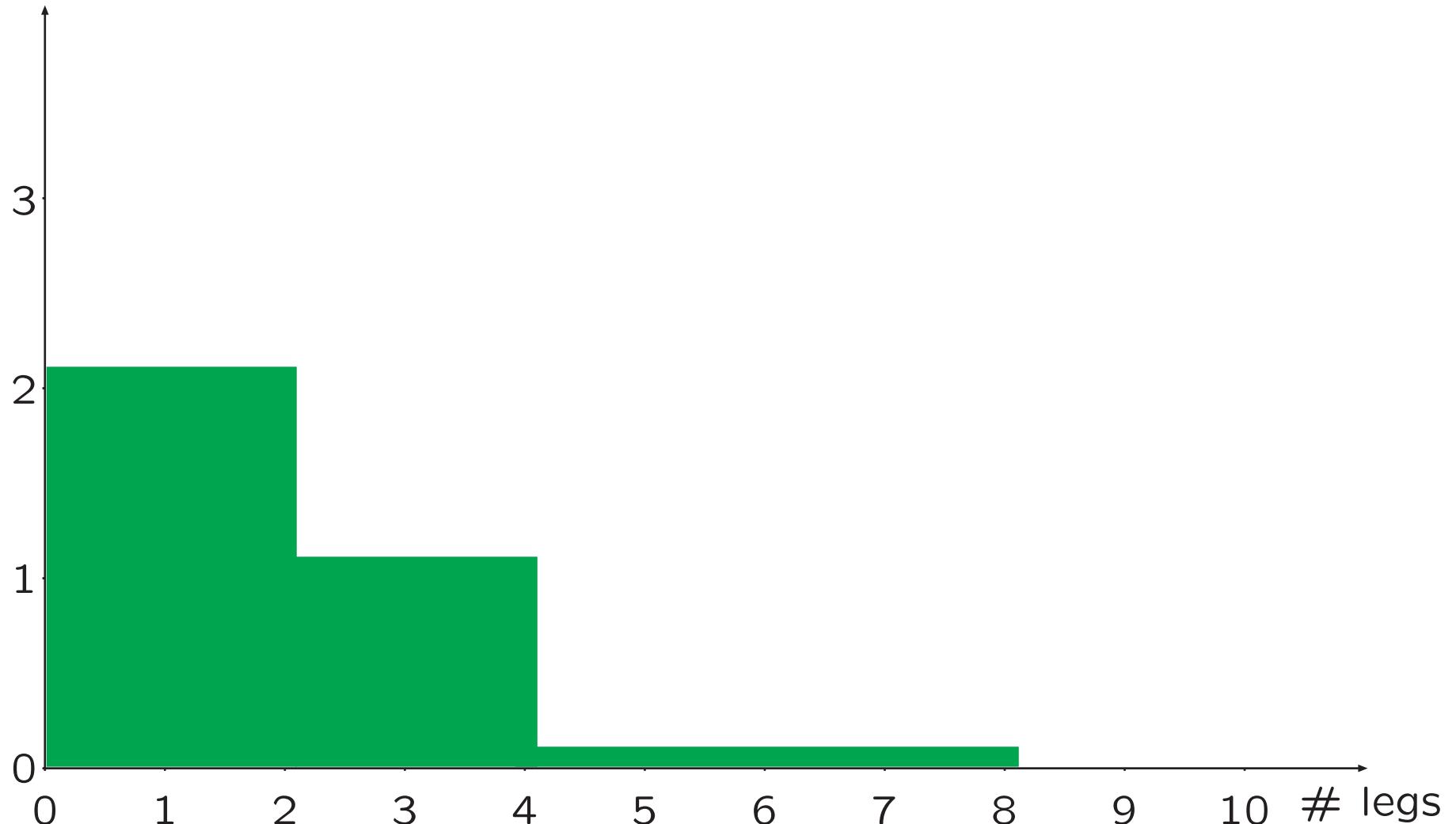
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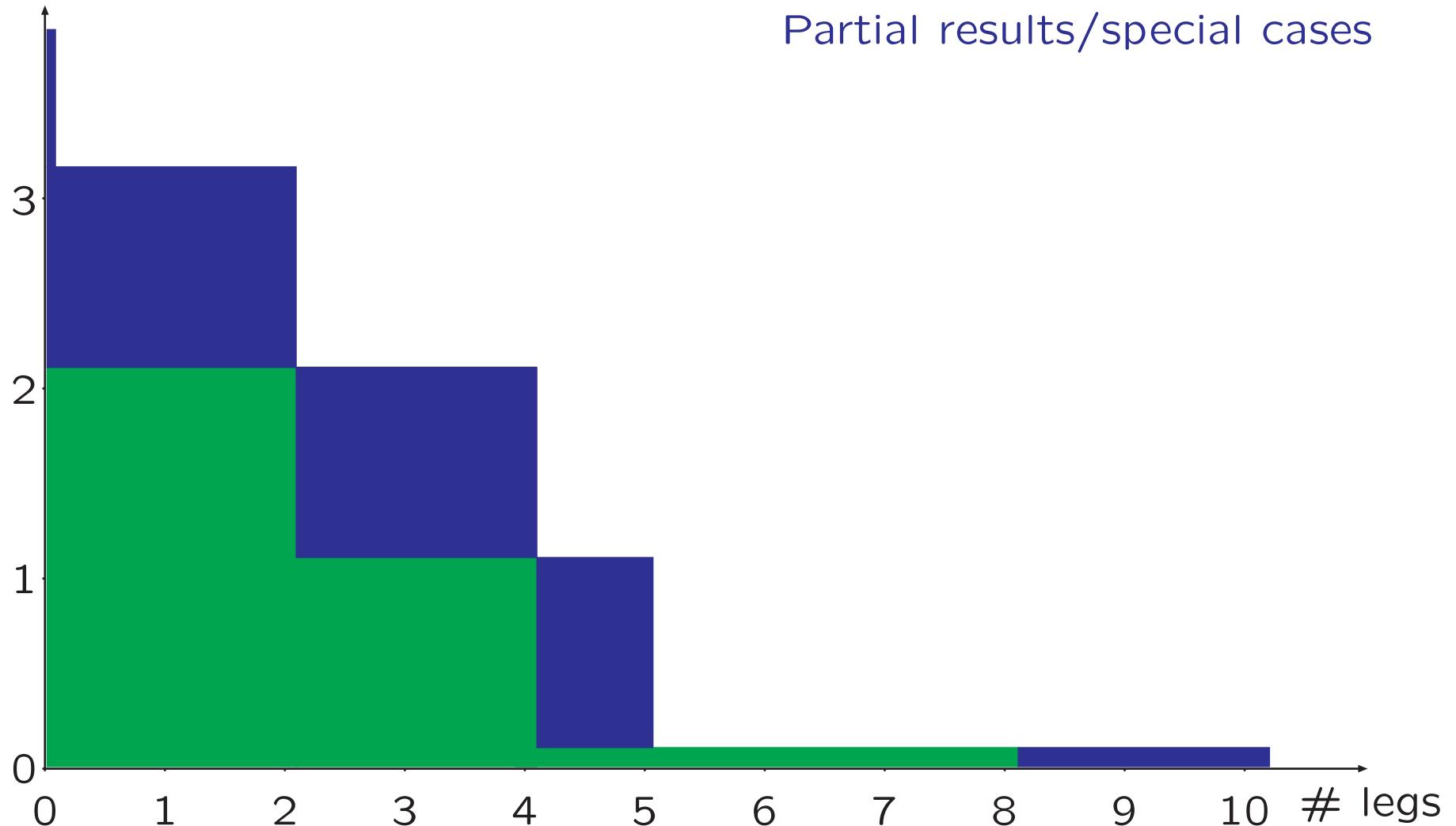
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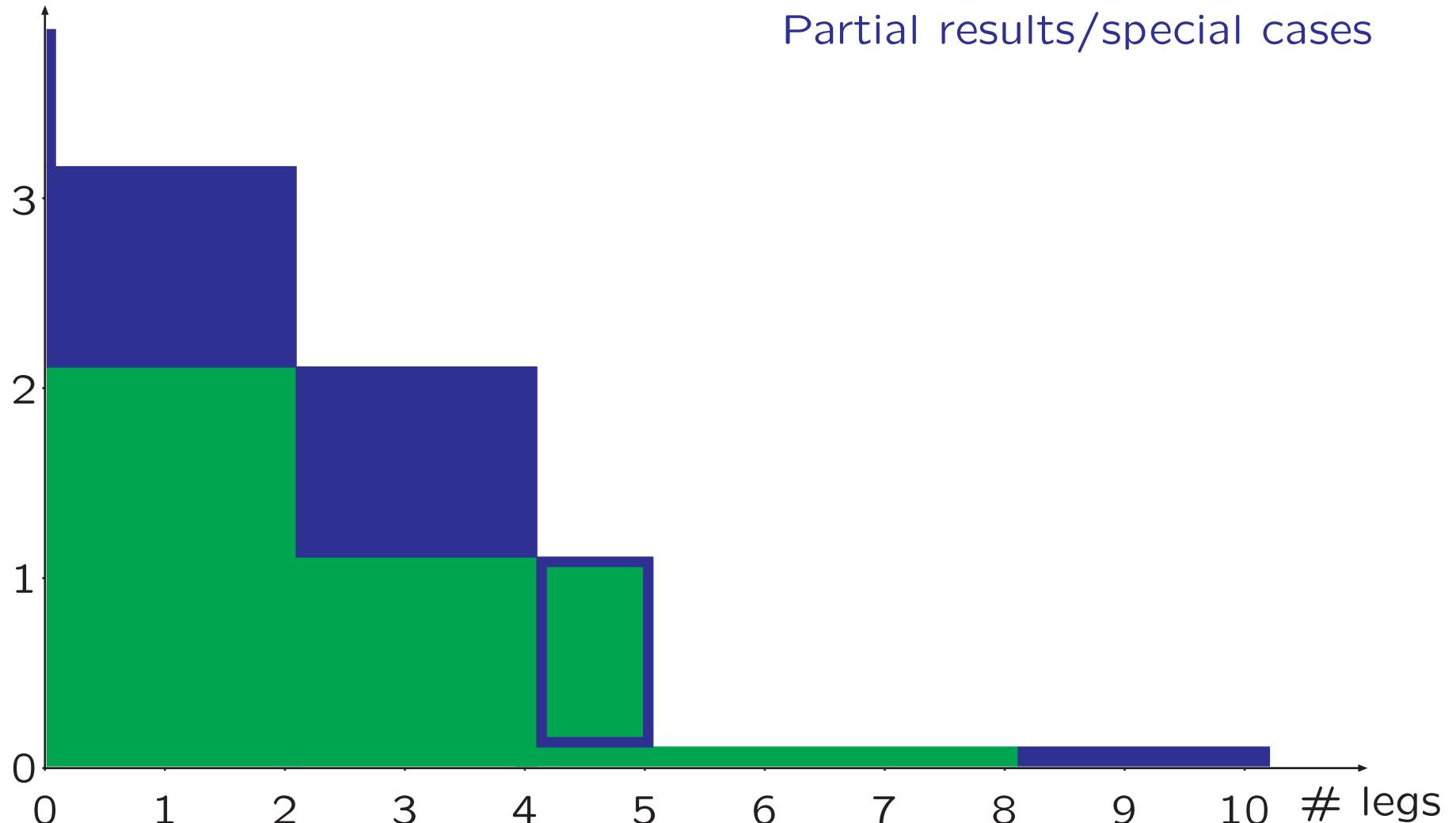
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Technique well established
Partial results/special cases

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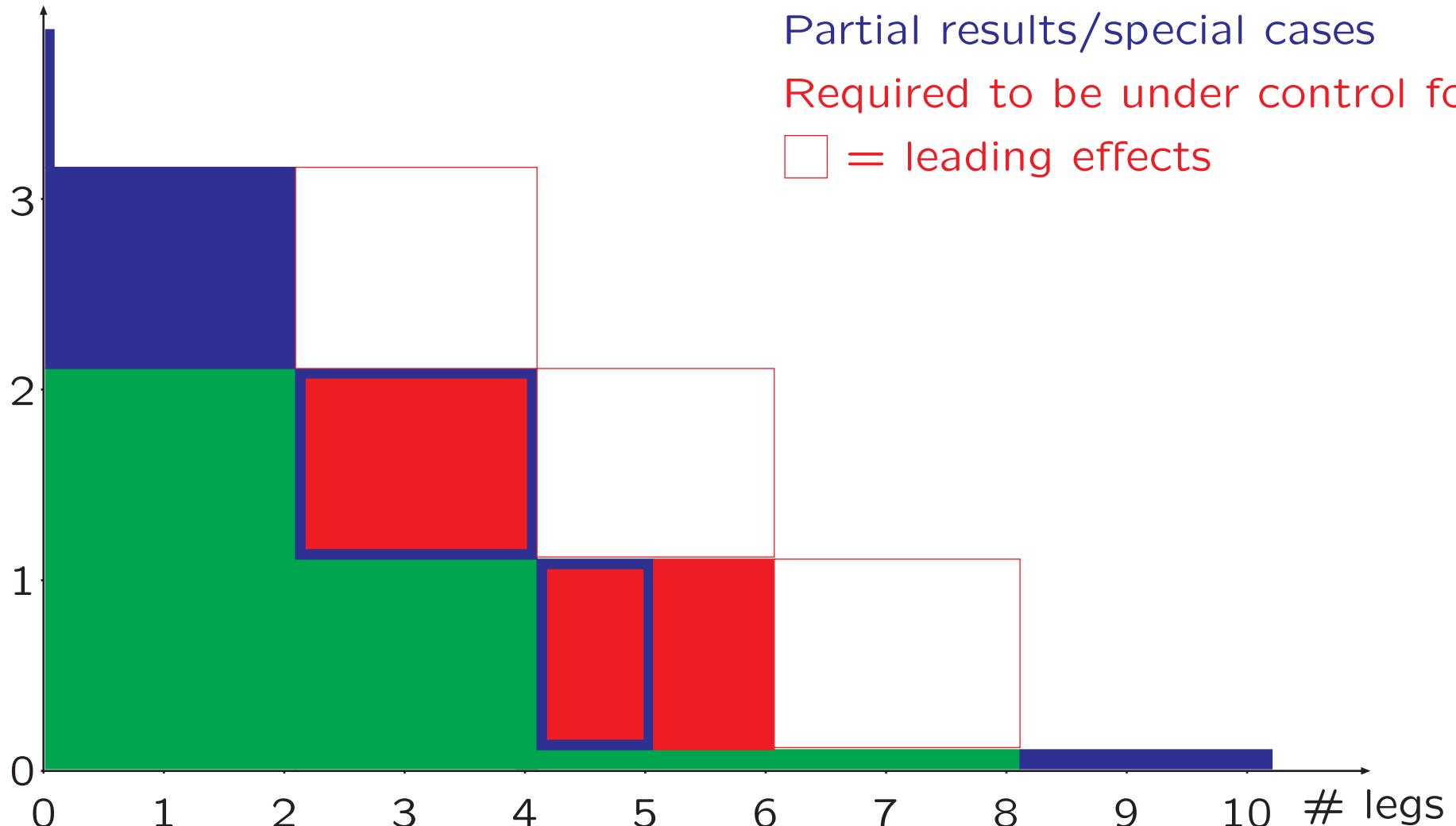
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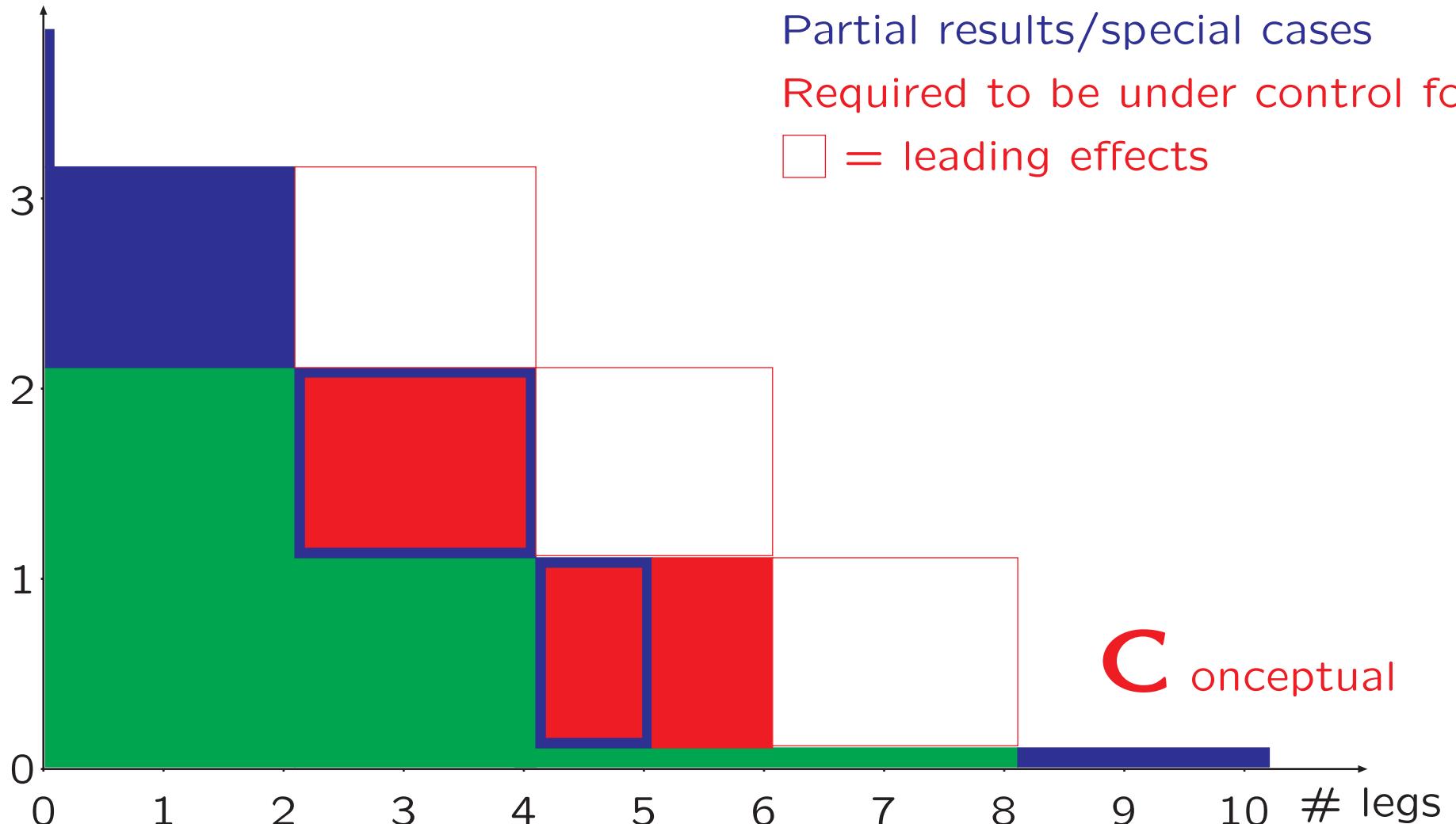
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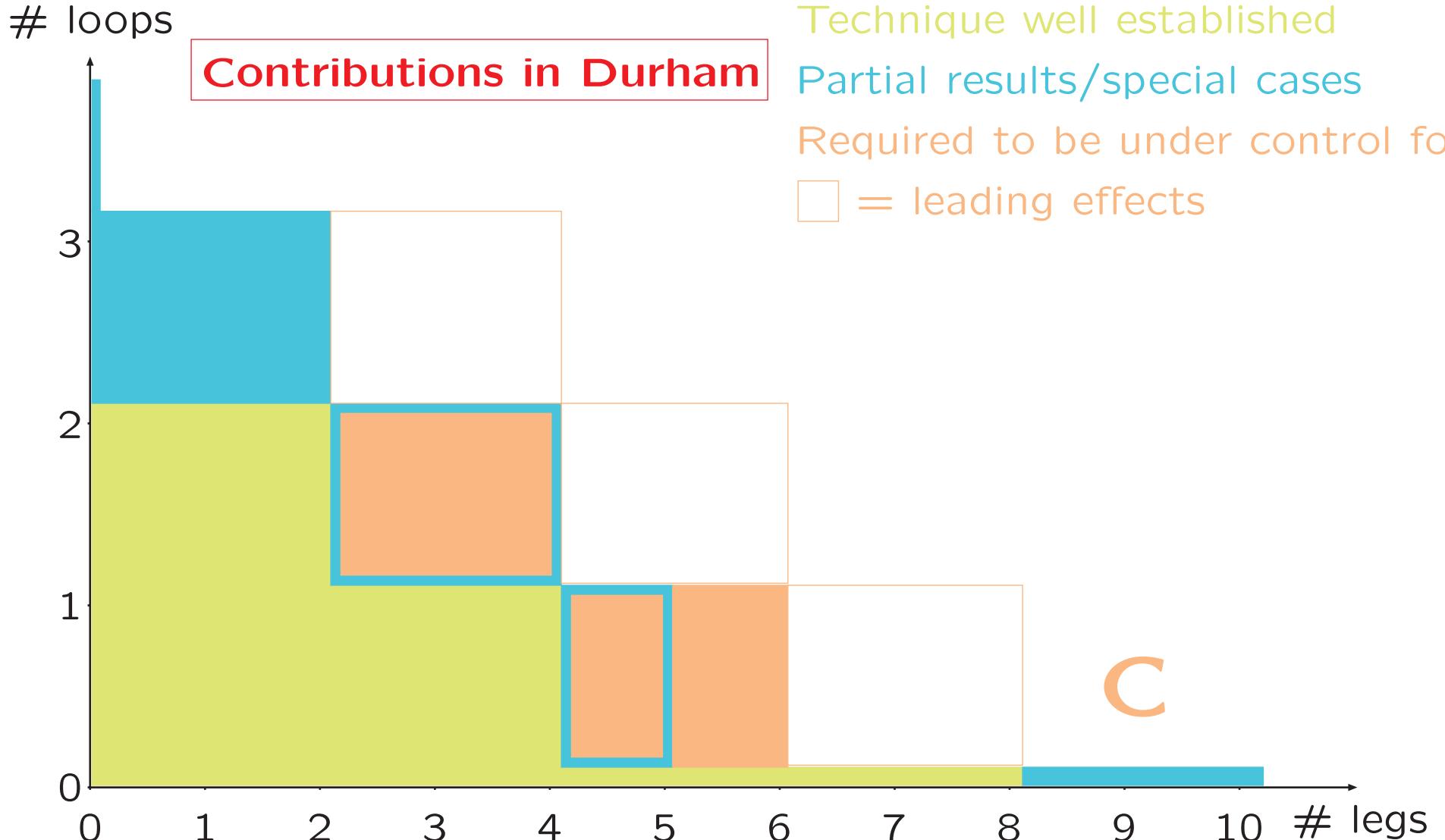


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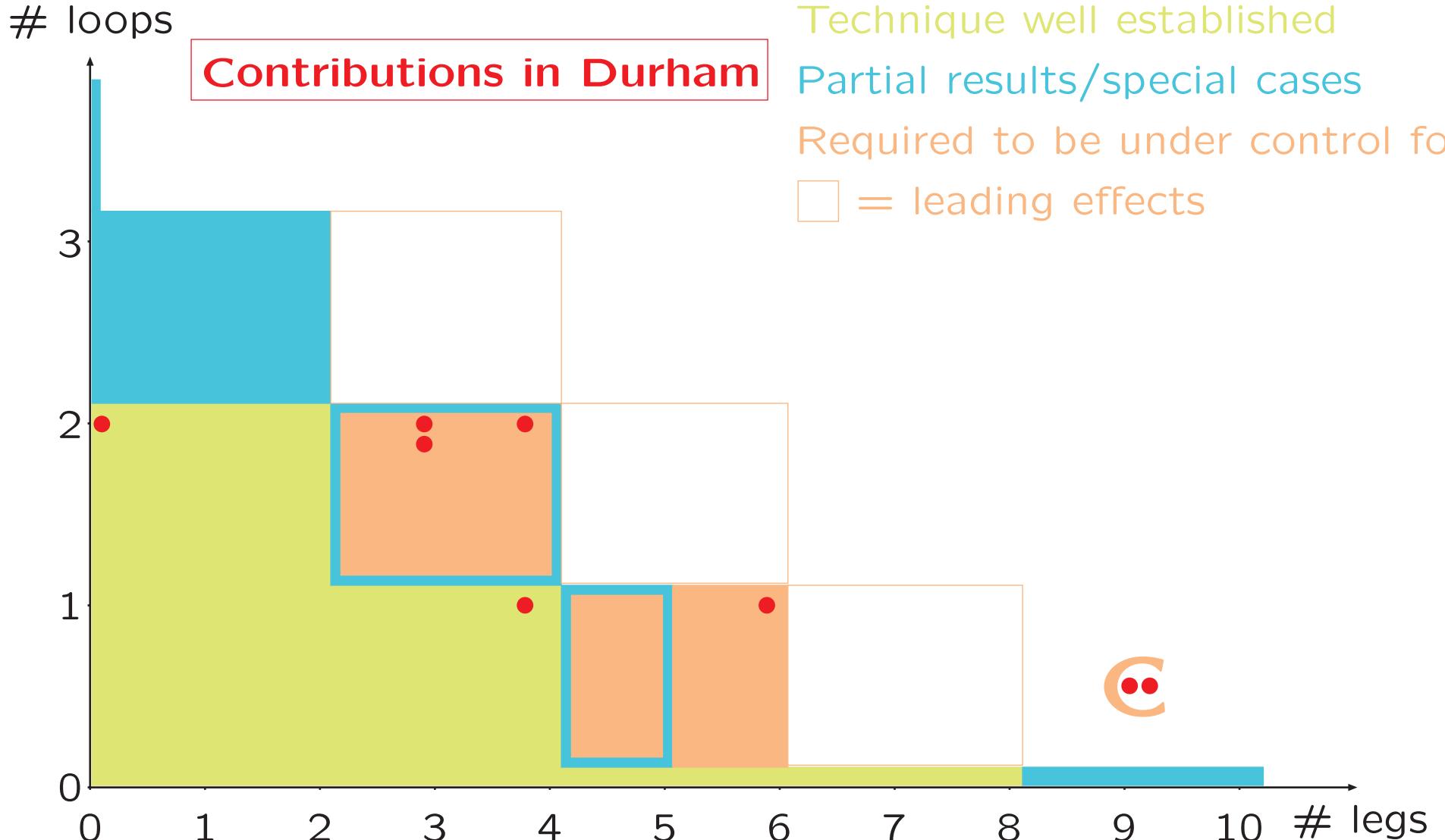
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loops

Contributions in Durham

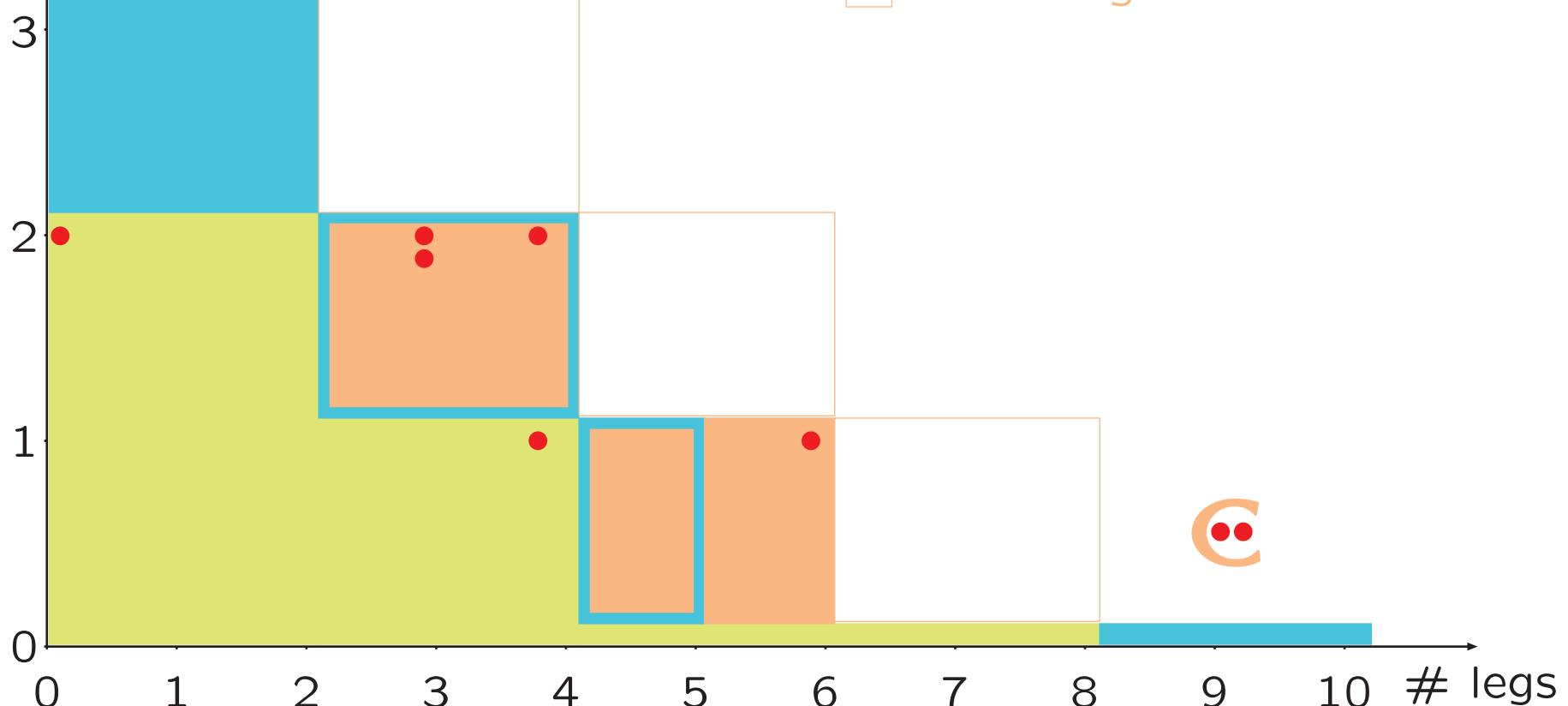
Compare to Paris

Technique well established

Partial results/special cases

Required to be under control for IL

□ = leading effects



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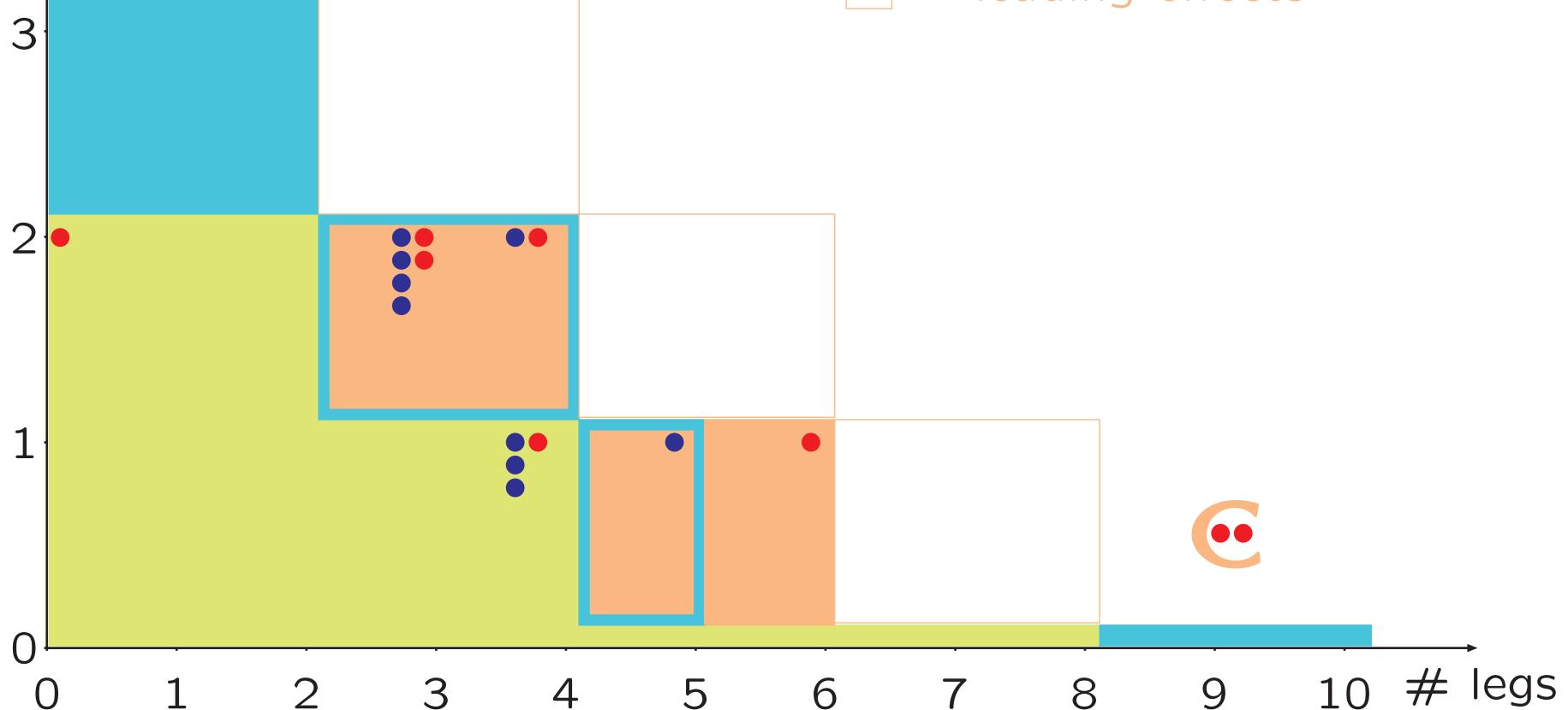
Compare to Paris

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vacuum graphs self-energies

$\Delta\rho$

Δr , masses

Bhaba

$1 \rightarrow 2, \sin^2 \theta_{\text{eff}}$

$2 \rightarrow 3$

$2 \rightarrow 2, 1 \rightarrow 3$

$ee \rightarrow 4f$

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loops

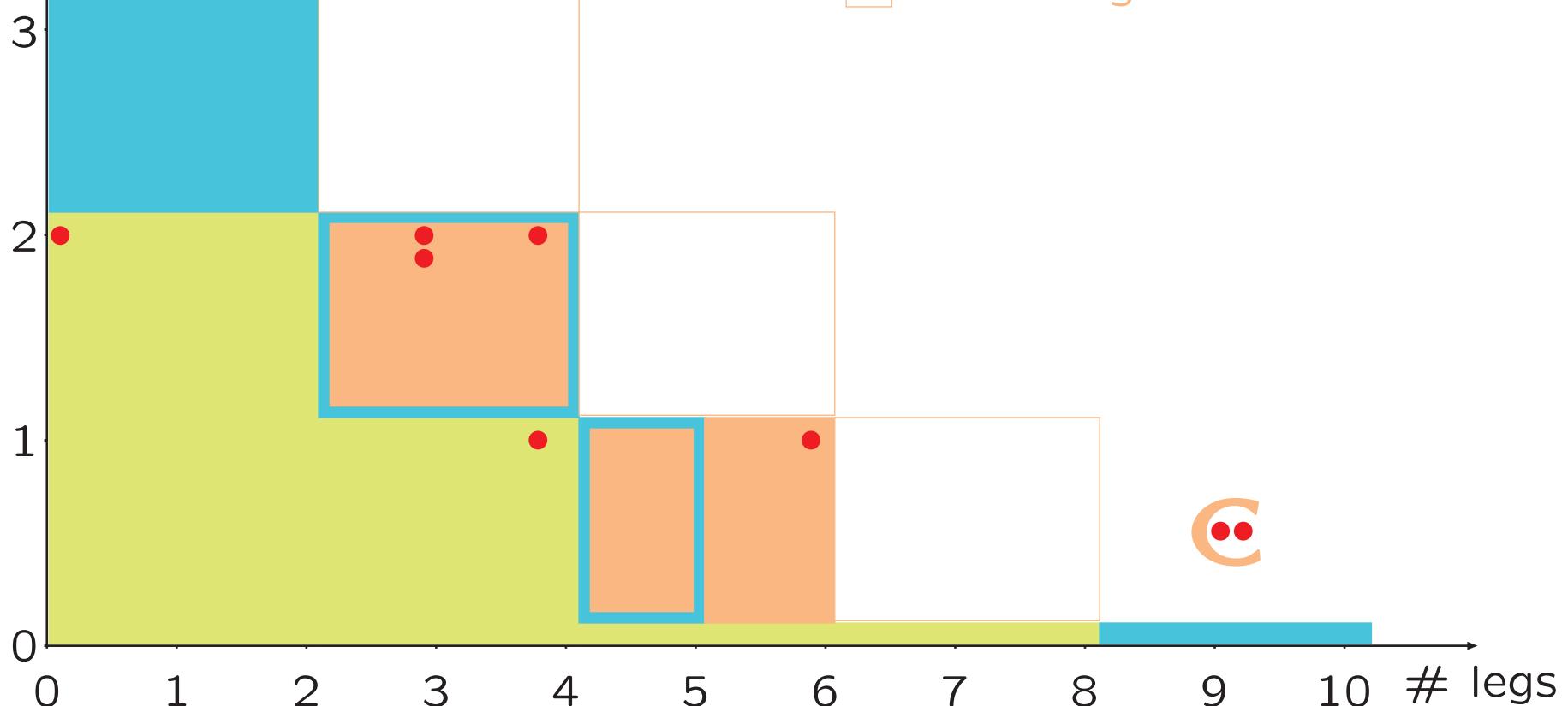
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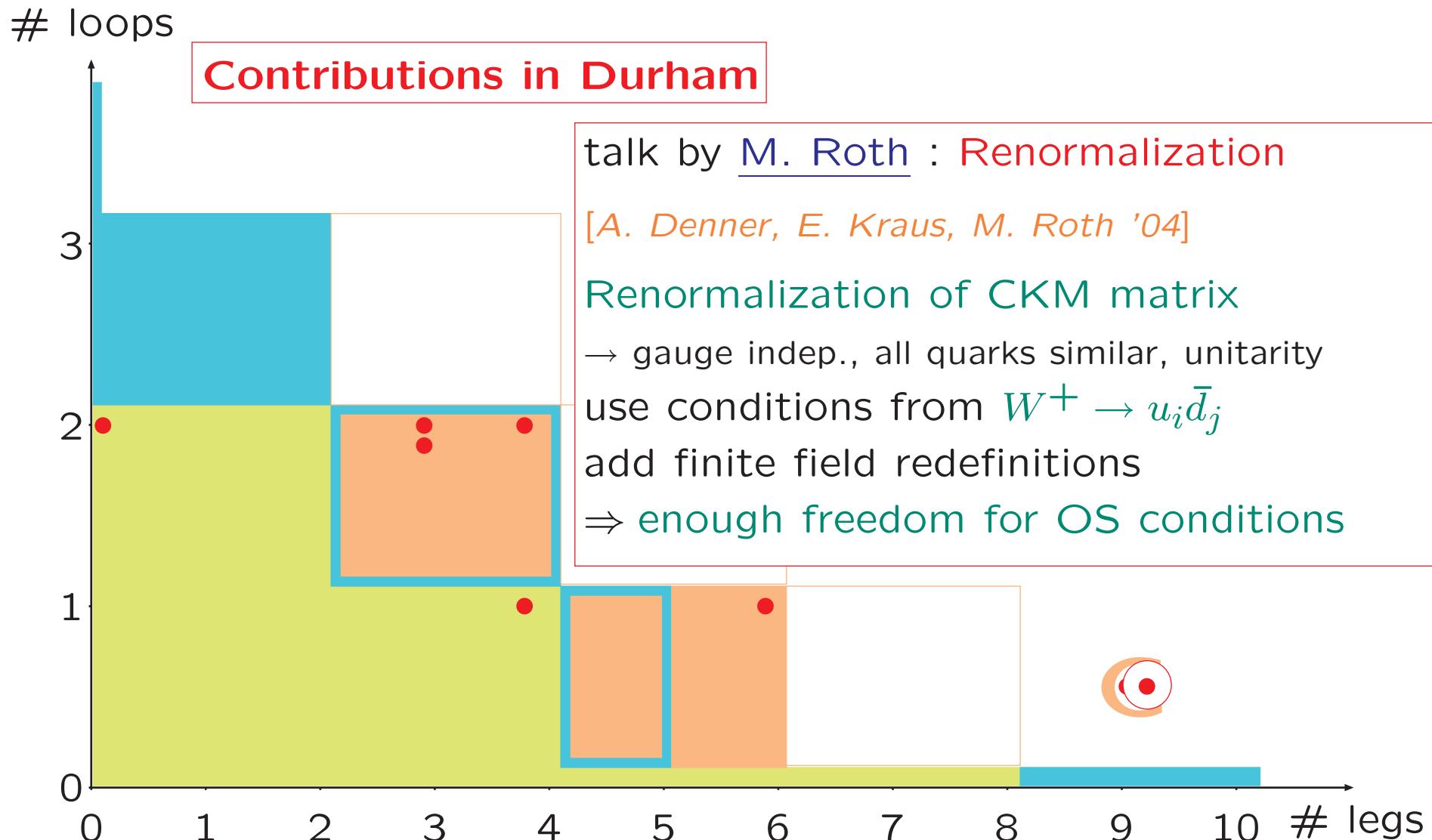
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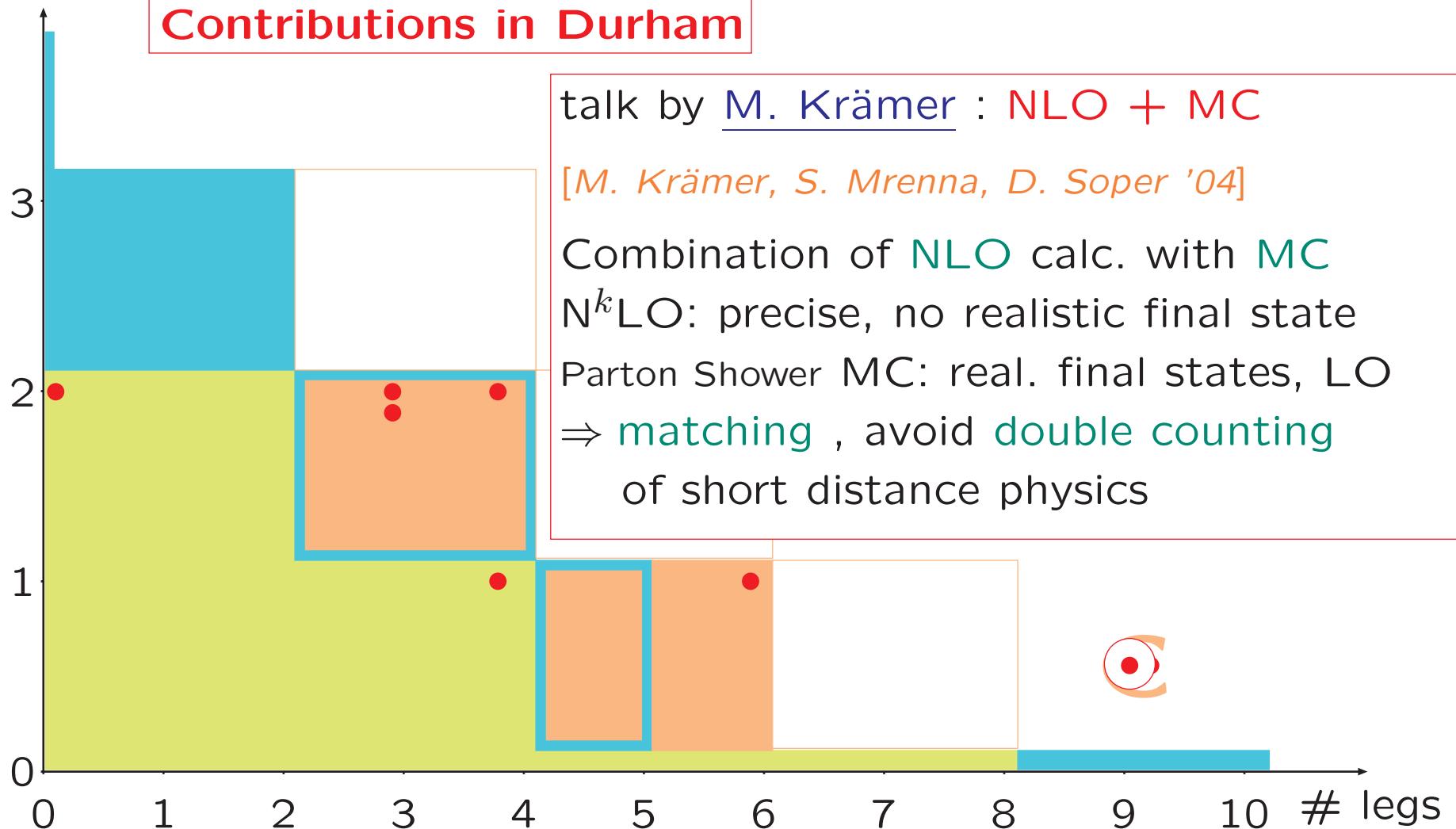
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vacuum graphs	self-energies	$2 \rightarrow 2, 1 \rightarrow 3$	$ee \rightarrow 4f$	$ee \rightarrow 6f$
$\Delta\rho$	Δr , masses	Bhaba	$ee \rightarrow 4f + \gamma$	
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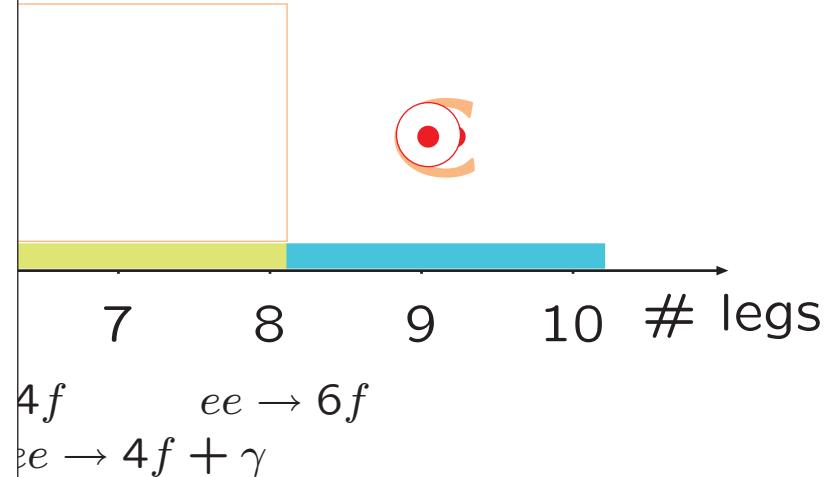
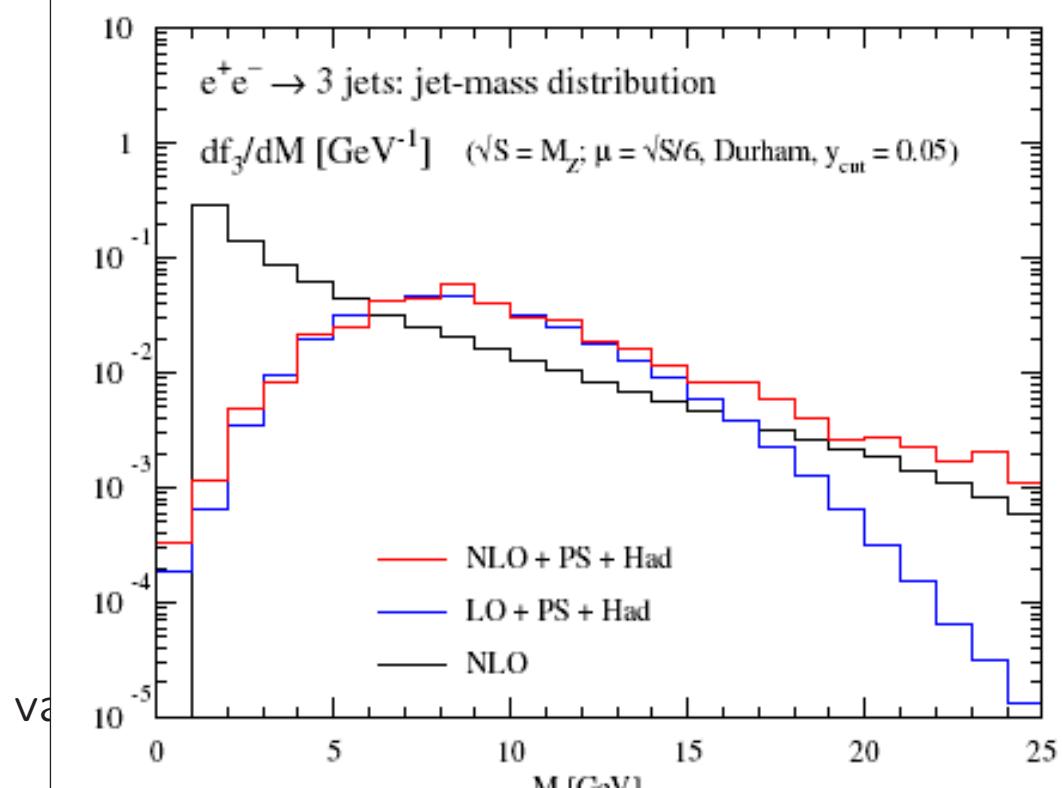
loops

Contributions in Durham

talk by M. Krämer : NLO + MC

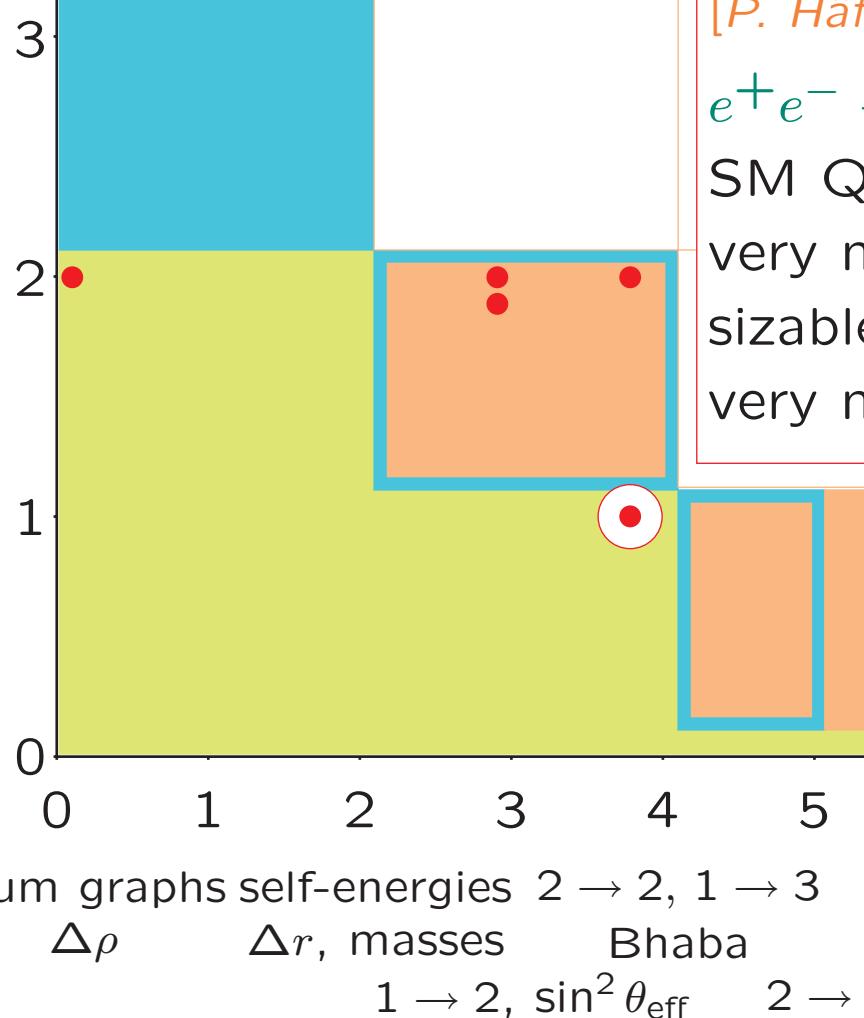
[M. Krämer, S. Mrenna, D. Soper '04]

n of NLO calc. with MC
use, no realistic final state
or MC: real. final states, LO
+, avoid double counting
distance physics



loops

Contributions in Durham



talk by M. Spira : 1 loop, $1 \rightarrow 3$, MSSM

[P. Häfliger, M. Spira '04]

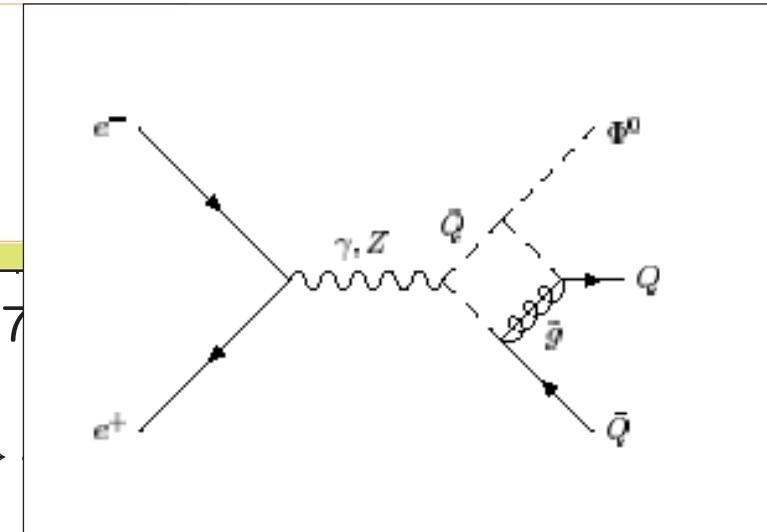
$e^+e^- \rightarrow Q\bar{Q}\phi$: 1L SUSY QCD, $\phi = h, H, A$

SM QCD + EW known (and relevant)

very new result \Rightarrow only SPS 5, 1b

sizable corrections: $\mathcal{O}(\pm 10\%)$

very new result \Rightarrow checks remain tbd



loops

Contributions in Durham

3

2

1

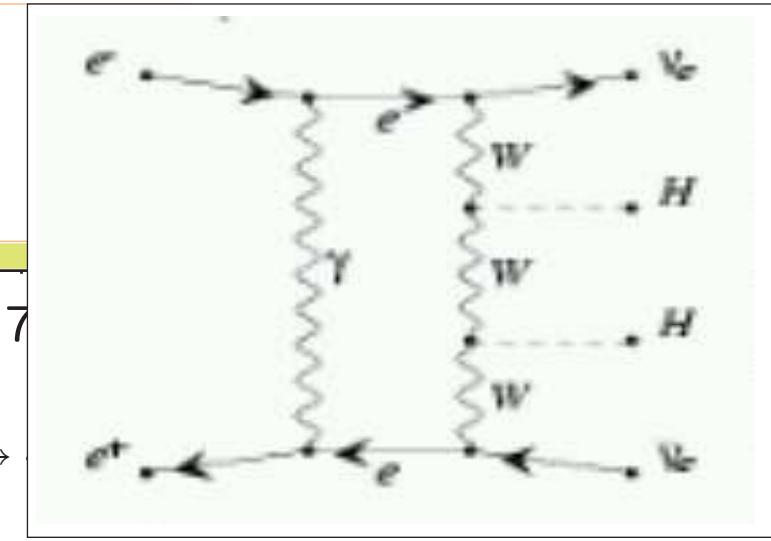
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vacuum graphs self-energies
 $\Delta\rho$ Δr , masses
 $1 \rightarrow 2$, $\sin^2 \theta_{\text{eff}}$

$2 \rightarrow 2$, $1 \rightarrow 3$
Bhaba
 $2 \rightarrow 3$

$ee \rightarrow 4f$
 $ee \rightarrow$

talk by Y. Yasui : 1 loop, $2 \rightarrow 4$, SM
[GRACE '04]
 $e^+e^- \rightarrow \nu\bar{\nu}HH$: first full EW $2 \rightarrow 4$
→ Higgs self-coupling measurement
3416 diagrams, 218 Pent. 74 Hex.
checks: UV/IR div., gauge par. independ.
corrections $\mathcal{O}(10\%)$ (top-loop in HHH)

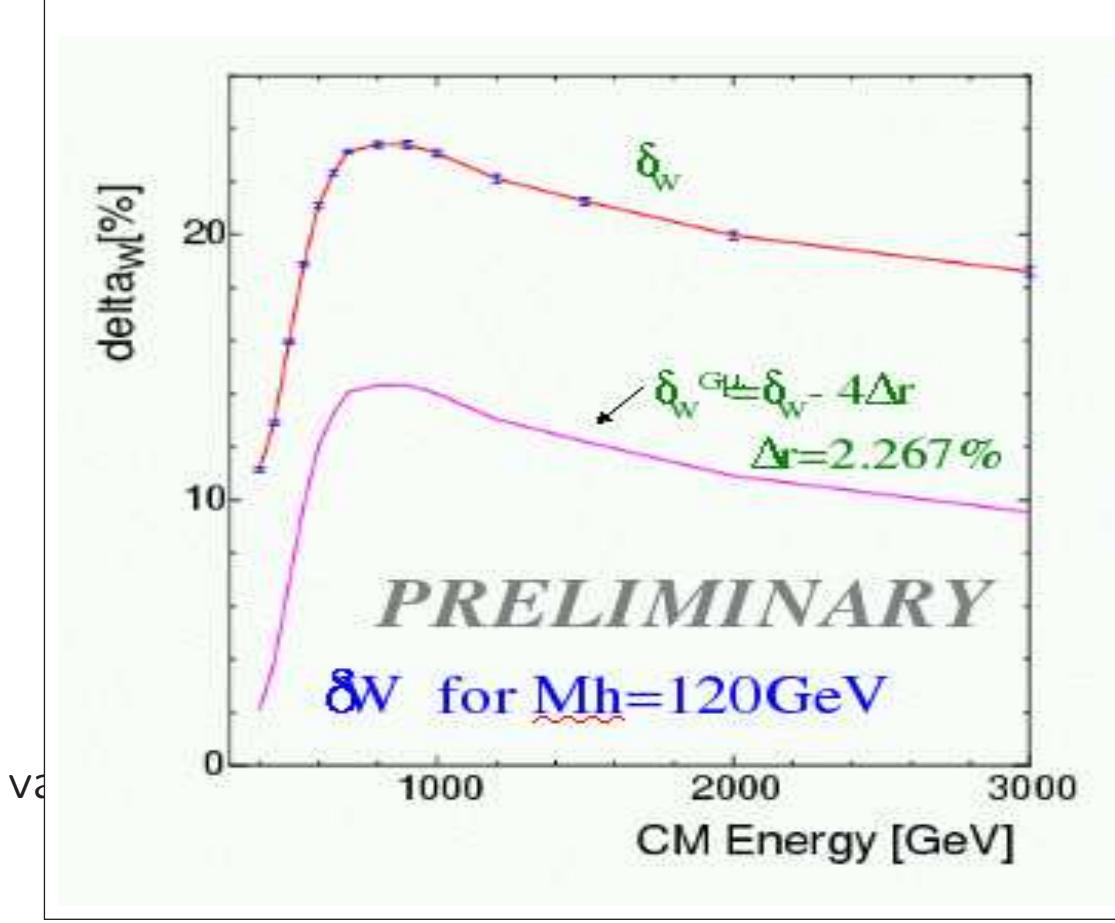


loops

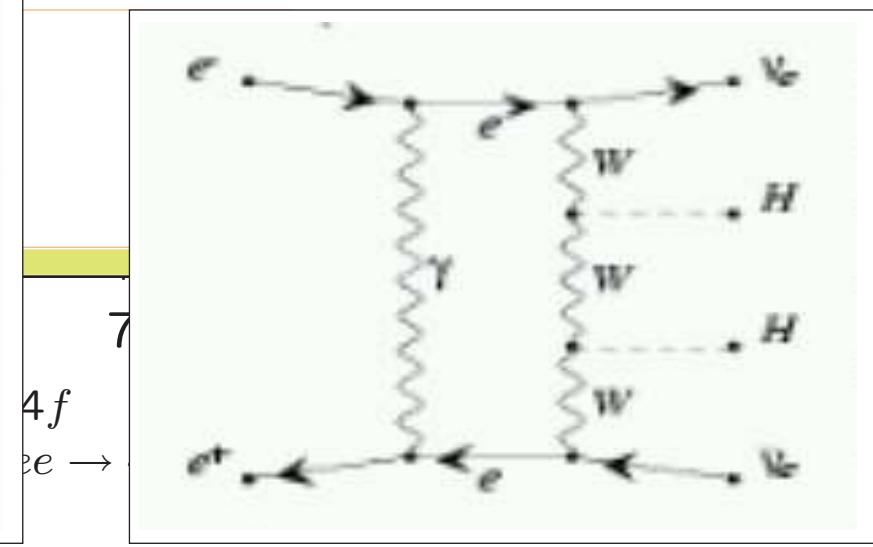
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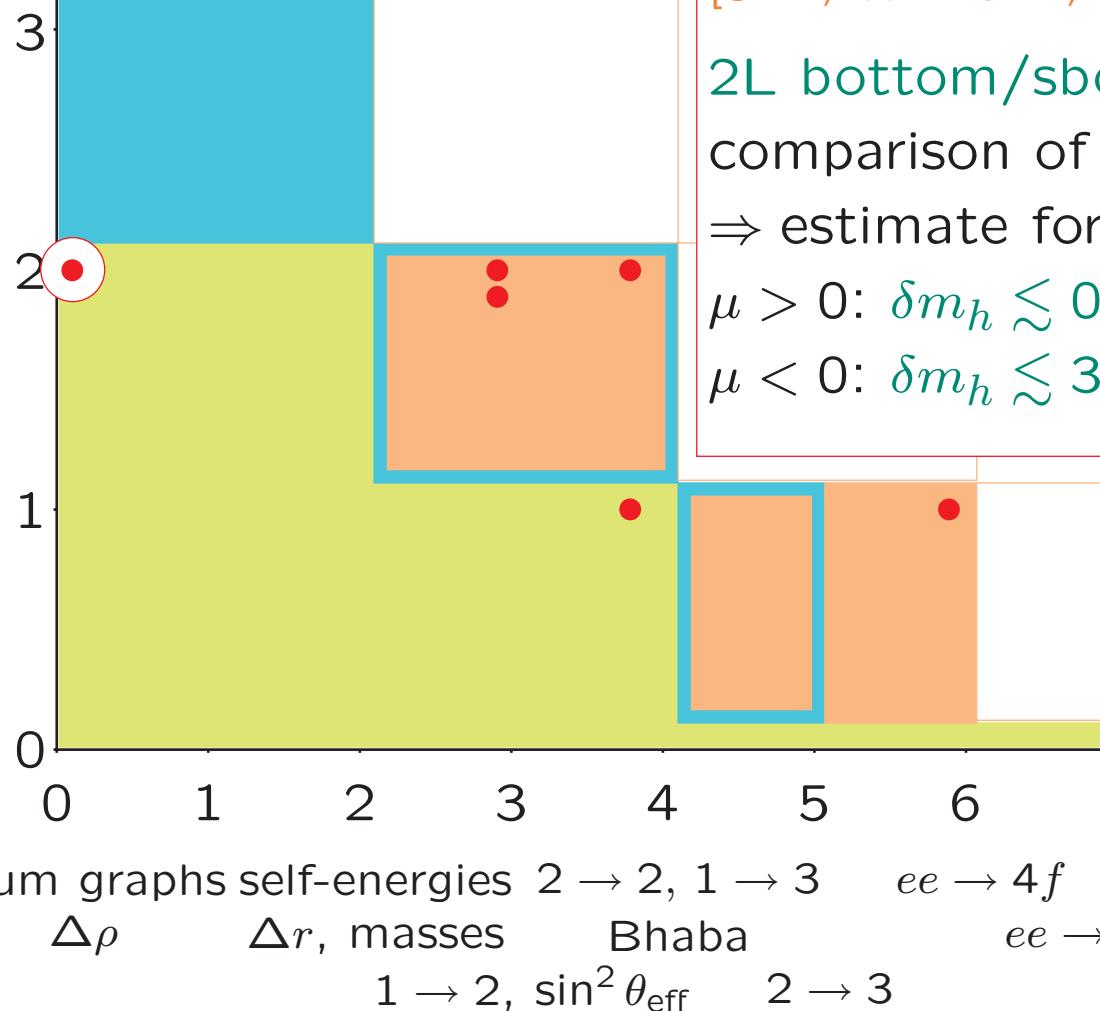


HH : first full EW $2 \rightarrow 4$
lf-coupling measurement
1 ms, 218 Pent. 74 Hex.
/IR div., gauge par. independ.
 $\mathcal{O}(10\%)$ (top-loop in HHH)



loops

Contributions in Durham



by H. Rzehak : 2L vacuum, MSSM + Ren.

[S.H., W. Hollik, H. Rzehak, G. Weiglein '04]

2L bottom/sbottom corr. to m_h : $\mathcal{O}(\alpha_s \alpha_b)$

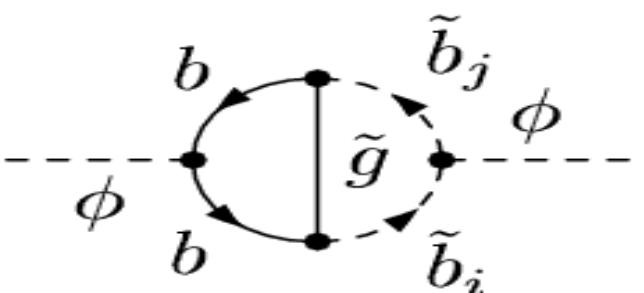
comparison of diff. renormalizations

⇒ estimate for missing higher-order corr.

$\mu > 0$: $\delta m_h \lesssim 0.1 \text{ GeV}$

$\mu < 0$: $\delta m_h \lesssim 3 \text{ GeV} \Rightarrow 3\text{L needed}$

LC: $\delta m_h^{\text{exp}} = 0.05 \text{ GeV}$



loops

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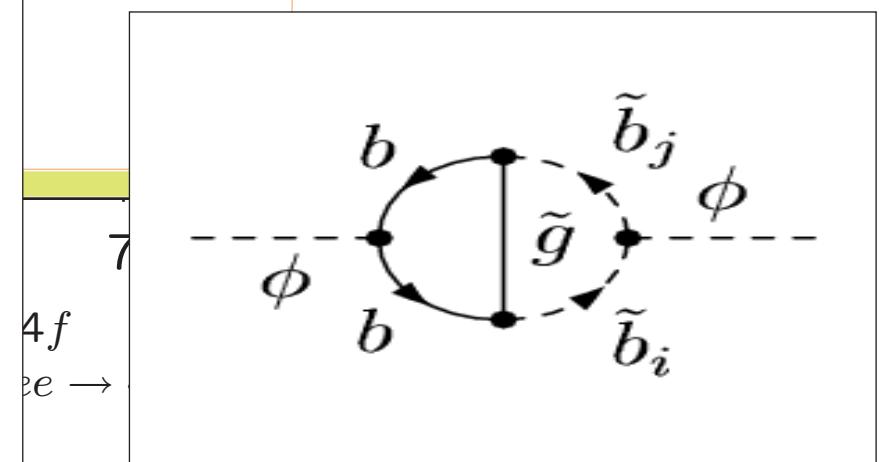
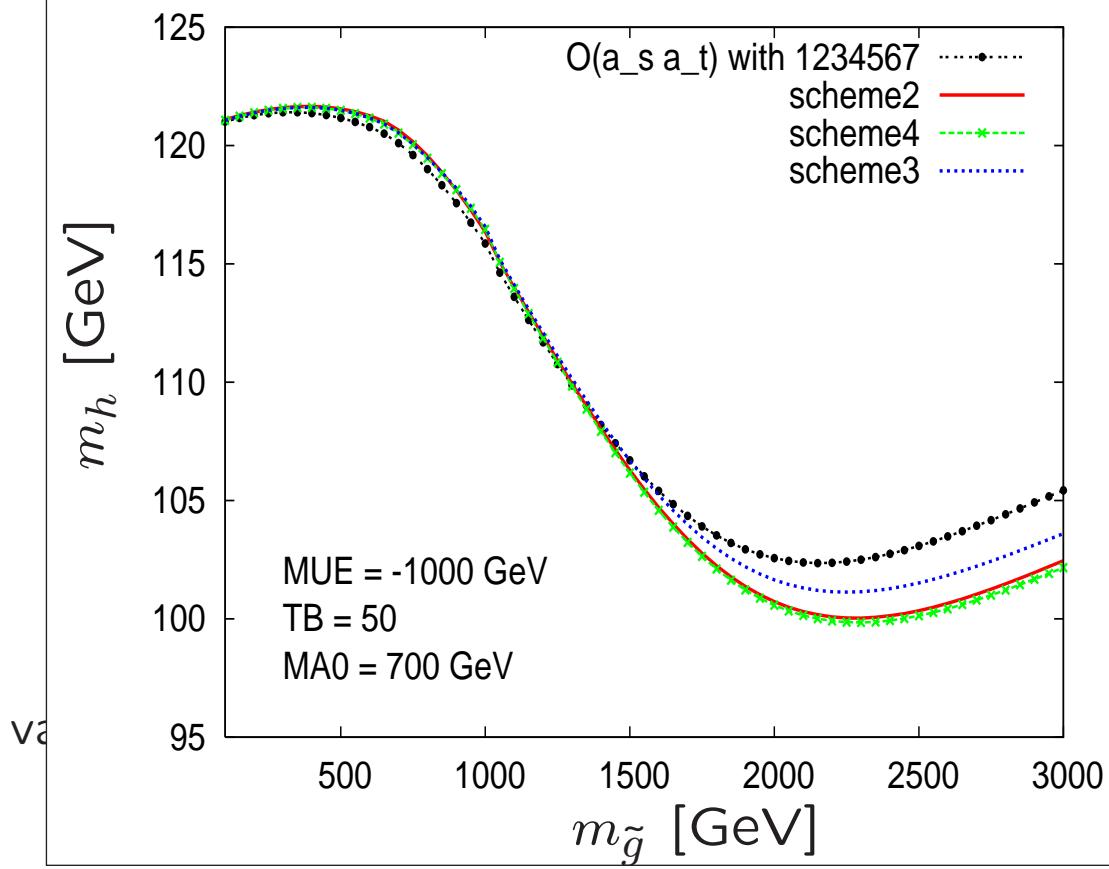
2L bottom/sbottom corr. to m_h : $\mathcal{O}(\alpha_s \alpha_b)$

of diff. renormalizations
for missing higher-order corr.

$\lesssim 0.1 \text{ GeV}$

$\lesssim 3 \text{ GeV} \Rightarrow 3\text{L needed}$

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talk by G. Weiglein : 2 loop, $1 \rightarrow 2$, SM

[Awramik, Czakon, Freitas, Weiglein '04]

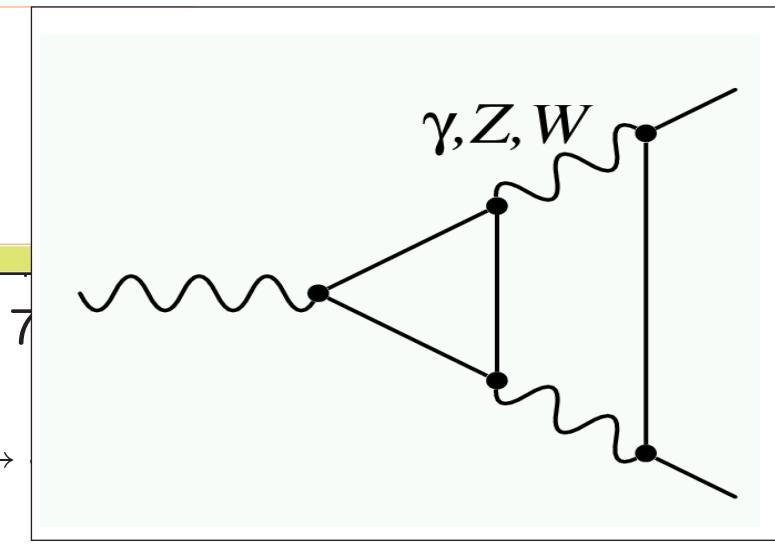
effective leptonic mixing angle $\sin^2 \theta_{\text{eff}}$

all diagrams with a closed fermion loop

$M_H = 100 \text{ GeV} \Rightarrow \delta \sin^2 \theta_{\text{eff}} = -4.5 \times 10^{-5}$

remaining unc.: $\delta \sin^2 \theta_{\text{eff}}^{\text{theo}} = \pm 5 \times 10^{-5}$

new blue band: $M_H < 260 \text{ GeV} @ 95\% \text{ CL}$



loops

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by D. Stöckinger : 2 loop, $1 \rightarrow 2$, MSSM

[S.H., D. Stöckinger, G. Weiglein '04]

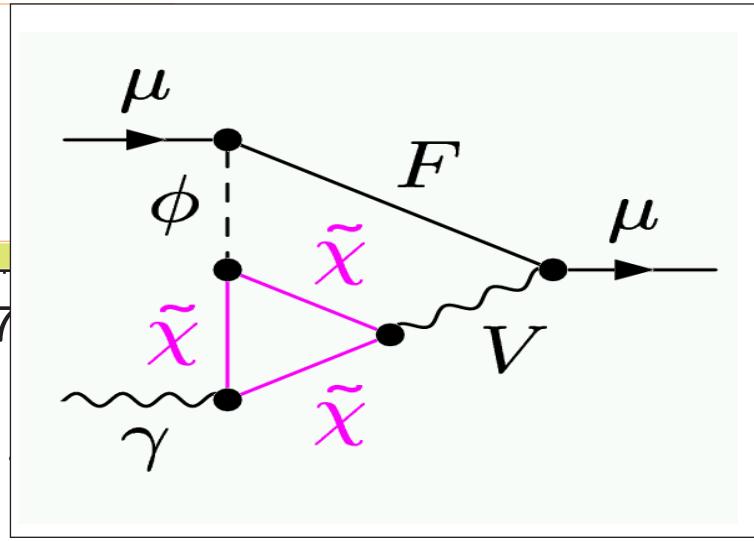
μ anomalous magnetic moment: $(g - 2)_\mu$

full MSSM \Rightarrow many scales

(advantage: favorite kinematic situation)

currently: $a_\mu^{\text{SM}} - a_\mu^{\text{exp}} \approx 25 \pm 9 \times 10^{-10}$

$2L \Rightarrow$ visible shift in MSSM prediction

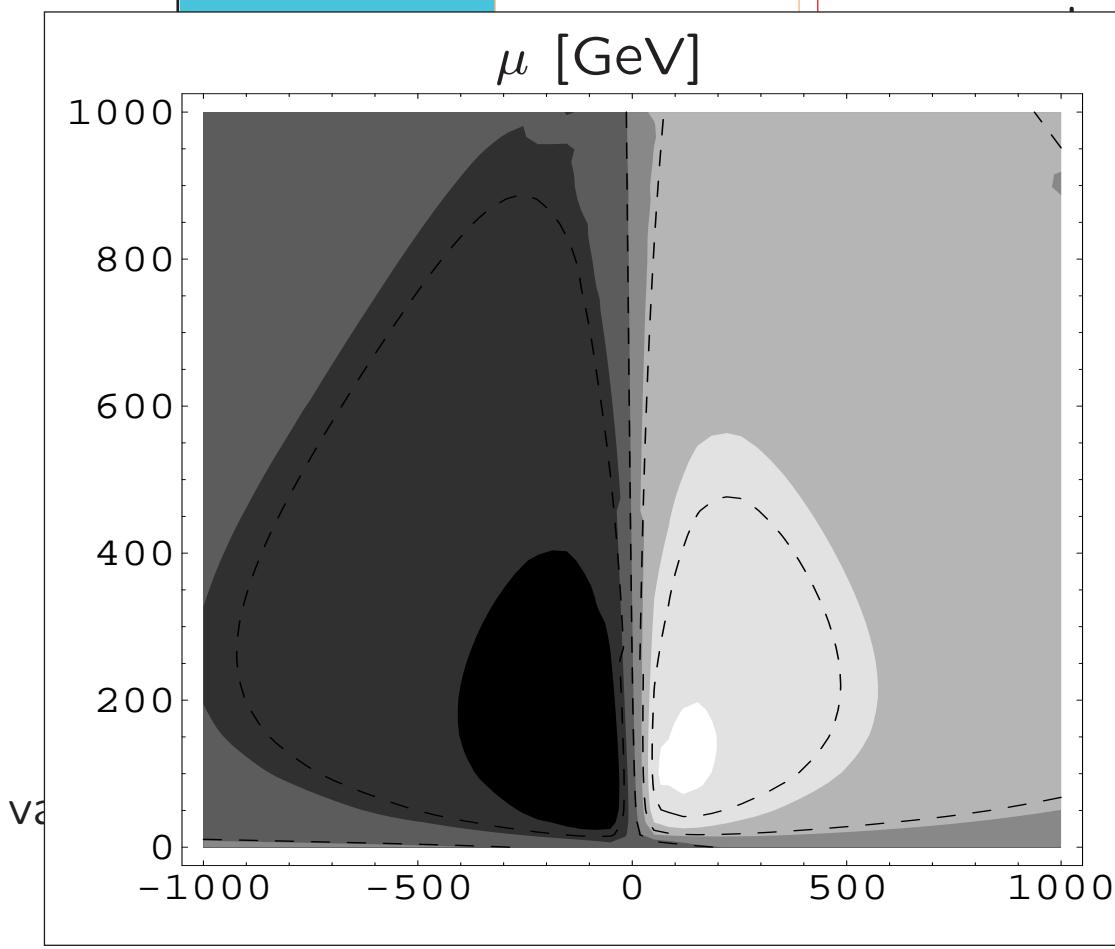


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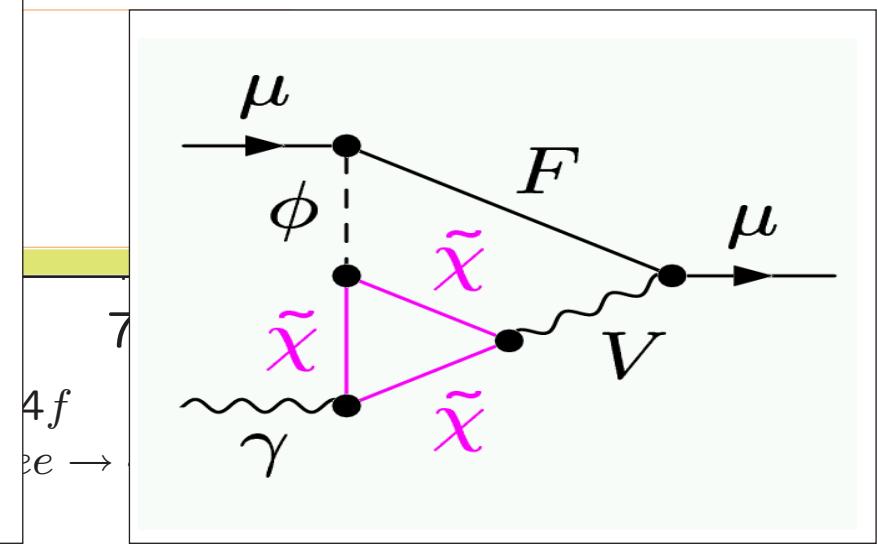
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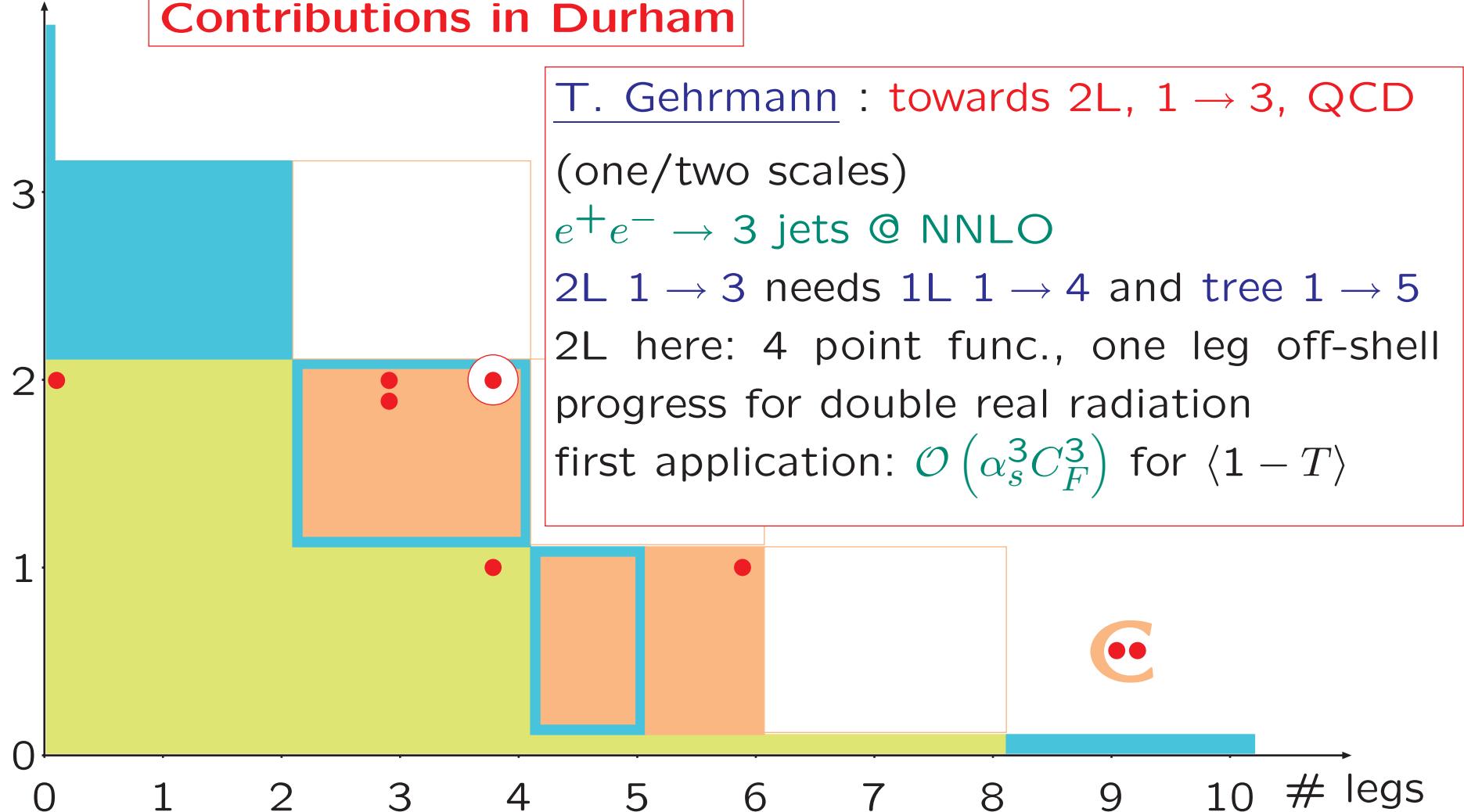


s magnetic moment: $(g - 2)_\mu$
⇒ many scales
(favorite kinematic situation)
 $a_\mu^{\text{exp}} \approx 25 \pm 9 \times 10^{-10}$
the shift in MSSM prediction



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T. Gehrmann : towards 2L, $1 \rightarrow 3$, QCD

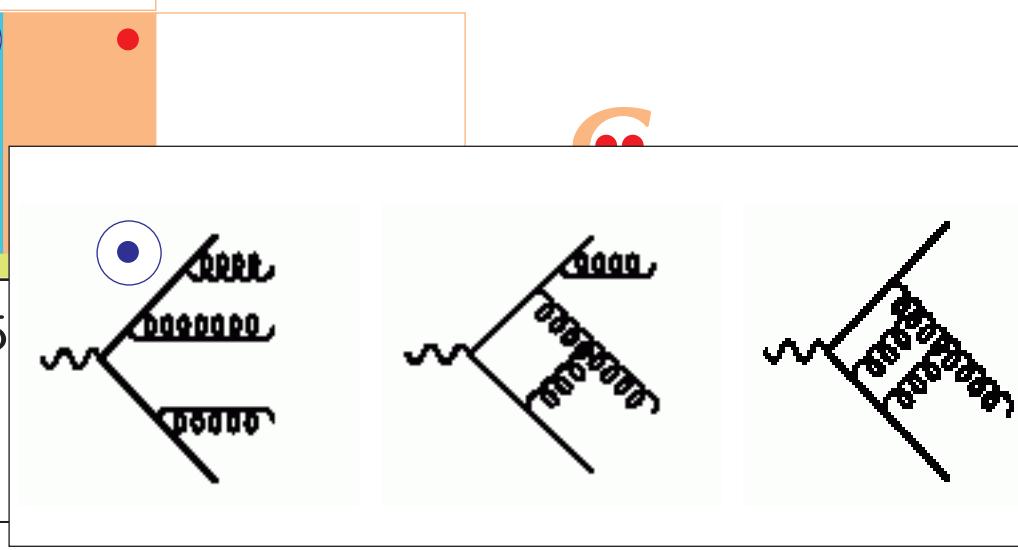
(one scale)

$e^+e^- \rightarrow 3 \text{ jets} @ \text{NNLO}$

2L $1 \rightarrow 3$ needs 1L $1 \rightarrow 4$ and tree $1 \rightarrow 5$

2L here: 4 point func., one leg off-shell
progress for double real radiation

first application: $\mathcal{O}(\alpha_s^3 C_F^3)$ for $\langle 1 - T \rangle$



Experimental situation:

Current/future Experiments

→ provide high accuracy measurements !

Theory situation:

measured observables have to be compared with theoretical predictions
(of your favorite model)

Measured data is only meaningful if it is matched with
theoretical calculations at the same level of accuracy

The great LC precision would be worthless without theory calculations

We have to start **NOW** to achieve necessary accuracy in time

Theoretical calculations should be viewed as an essential part of all
future High Energy Physics programs